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DIODE

STEP STRESS TESTING PROGRAM

MSFC/NASA CONTRACT NUMBER
NAS8-31944

FINAL REPORT
FOR
JANTX 1N5417

JANUARY 1979

Prepared
For

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Marshall Space Flight Center, Alabama 35812

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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transisters, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the diode JANTX1N5417 manufactured by MICRO SEMICONDUCTOR and SEMTECH.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-Speed Computer-Controlled Tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_F and the current was varied in order to comply with the specified power rating for the device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were

submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for a total of 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Micro Semiconductor. The Micro Semiconductor sample lot completed 1750 hours of Group I Testing before the lot was stopped because more than 50% of the devices failed at this point. This sample lot experienced 12 catastrophic failures. The first two failures occurred 500 hours into the 125% MRP. Serial Numbers 7638 and 7639 were removed from the testing as visual-catastrohic failures because the cathode leads detached from the stress. The next failure occurred 25 hours into the 1[illegible]% MRP step. Serial Number 7636 was removed from the testing as a visual catastrophic failure because the cathode lead detached from the stress. The next failure occurred 50 hours into the 150% MRP step. Serial Number 7648 was removed from the testing as a visual-catastrophic failure because the cathode lead detached from the stress. The next three failures occurred 150 hours into the 150% MRP step. Serial Numbers 7640, 7645 and 7646 were removed from the testing as visual-catastrophic failures because the cathode leads detached from the stress. The last five failures occurred 250 hours into the 150% MRP step. Serial Numbers 7641, 7642, 7643, 7644, and 7647 were removed from the testing as visual-catastrophic failures because the cathode leads detached from the stress. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 8.7nA from an initial mean of 333.9nA to a final mean of 325.2nA.

2) The mean value for V_{F1} changed .006V from

an initial mean of 1.099V to a final mean of 1.105V.

3) The mean value for V_{F2} changed 2.4mV from an initial mean of 915.4mV to a final mean of 917.8mV.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Semtech. The Semtech sample lot completed 2000 hours of Group I Testing before the lot was stopped because 50% of the devices failed at this point. This sample lot experienced eight catastrophic failures. The first seven failures occurred 50 hours into the 100% MRP step. Serial Numbers 7603, 7605, 7606, 7607, 7608, 7609 and 7610 failed because of excessive I_R leakage. The last failure occurred 500 hours into the 150% MRP step. Serial Number 7577 was removed from the testing as a visual-catastrophic failure because the cathode lead detached from the stress. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 202.11nA from an initial mean of 87.29nA to a final mean of 289.4nA.

2) The mean value for V_{F1} changed .019V from an initial mean of 1.285V to a final mean of 1.266V.

3) The mean value for V_{F2} changed 20.4mV from an initial mean of 947.7mV to a final mean of 927.3mV.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary. Table 4 outlines the test results of Group I - Power Stress Process, for each of the three electrical parameters and all measurement points for both Micro Semiconductor and Semtech.

3.2 Group II - Temperature Stress I

3.2.1 Micro Semiconductor. The Micro Semiconductor sample lot completed the entire 1600-hour Group II Testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 201.7nA from an initial mean of 180.5nA to a final mean of 382.2nA.

2) The mean value for V_{F1} changed 6.689V from an initial mean of 1.085V to a final mean of 7.774V.

3) The mean value for V_{F2} changed 4.7mV from an initial mean of 911.0mV to a final mean of 915.7mV.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Semtech. The Semtech sample lot completed the entire 1600-hour Group II Testing with two catastrophic failures. The two failures occurred 1600 hours into the 300°C-temperature step. Serial Numbers 7586 and 7612 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 40.178µA from an initial mean of 82.10nA to a final mean of

40.26μA.

2) The mean value for V_{F1} changed .035V from an initial mean of 1.299V to a final mean of 1.264V.

3) The mean value for V_{F2} changed 13.9mV from an initial mean of 943.0mV to a final mean of 929.1mV.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 of this report outlines the results of Group II - Temperature Stress I Testing, for each of the three electrical parameters and all of the measurement points pertaining to both Micro Semiconductor and Semtech.

3.3 Group III - Temperature Stress II

3.3.1 Micro Semiconductor. The Micro Semiconductor sample lot completed the entire 112-hour Group III Testing with no catastrophic failures. Typical characteristics of this sample lot were:

1) The mean value for I_R changed 104.5nA from an initial mean of 179.3nA to a final mean of 283.8nA.

2) The mean value for V_{F1} changed .02V from an initial mean of 1.096V to a final mean of 1.116V.

3) The mean value for V_{F2} changed 3.5mV from an initial mean of 923.9mV to a final mean of 927.4mV.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Semtech. The Semtech sample lot completed the entire 112-hour Group III Testing with five catastrophic failures. The first four failures occurred 16 hours into the 150°C-temperature step. Serial Numbers 7619, 7621, 7625, and 7626 failed because of excessive I_R leakage. The last failure occurred 16 hours into the 175°C-temperature step. Serial Number 7622 failed because of excessive I_R leakage. Typical characteristics of this sample lot were:

1) The mean value for I_R changed 199.08nA from an initial mean of 87.82nA to a final mean of 286.9nA.

2) The mean value for V_{F1} changed .009V from an initial mean of 1.267V to a final mean of 1.258V.

3) The mean value for V_{F2} changed 5.0mV from an initial mean of 939.8mV to a final mean of 934.8mV.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II Testing, for each of the three electrical parameters and all of the measurement points pertaining to both Micro Semiconductor and Semtech.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the changes in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature

stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 were used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5, respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

The only stress test that did significant damage to both manufacturers was the Group I - Power Stress Testing. Note that the majority of the Micro Semiconductor devices failed because of leads detaching from the stress. On the other hand, the majority of the Semtech devices failed because of excessive I_R leakage due to stress. Both manufacturers' devices failed due to thermal effects caused by the excess power of the stress test.

A plot showing cumulative failure distribution for Groups II and III was drawn for the Semtech sample lot Group III, but due to an insufficient amount of failure points in the Group II Testing, the activation energy could not be calculated. The activation energy could not be calculated due to an absence of failures in the Groups II and III

for the Micro Semiconductor sample lot.
A broken circle around a marked point, on the graphs, indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was drawn using the least square method.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{eV}$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^{\circ}$C of 16% failure for Group II.

T_2 = temperature in $^{\circ}$C of 16% failure for Group III.

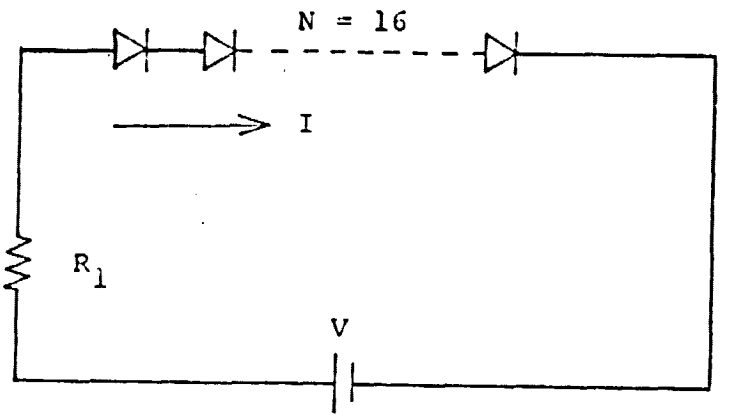
NOTE:

* Conditions for failure:

A) Open or short

B) Leakage exceeds the maximum limit by 100 times

C) Other parameters exceed MIL limits by 50% or more.

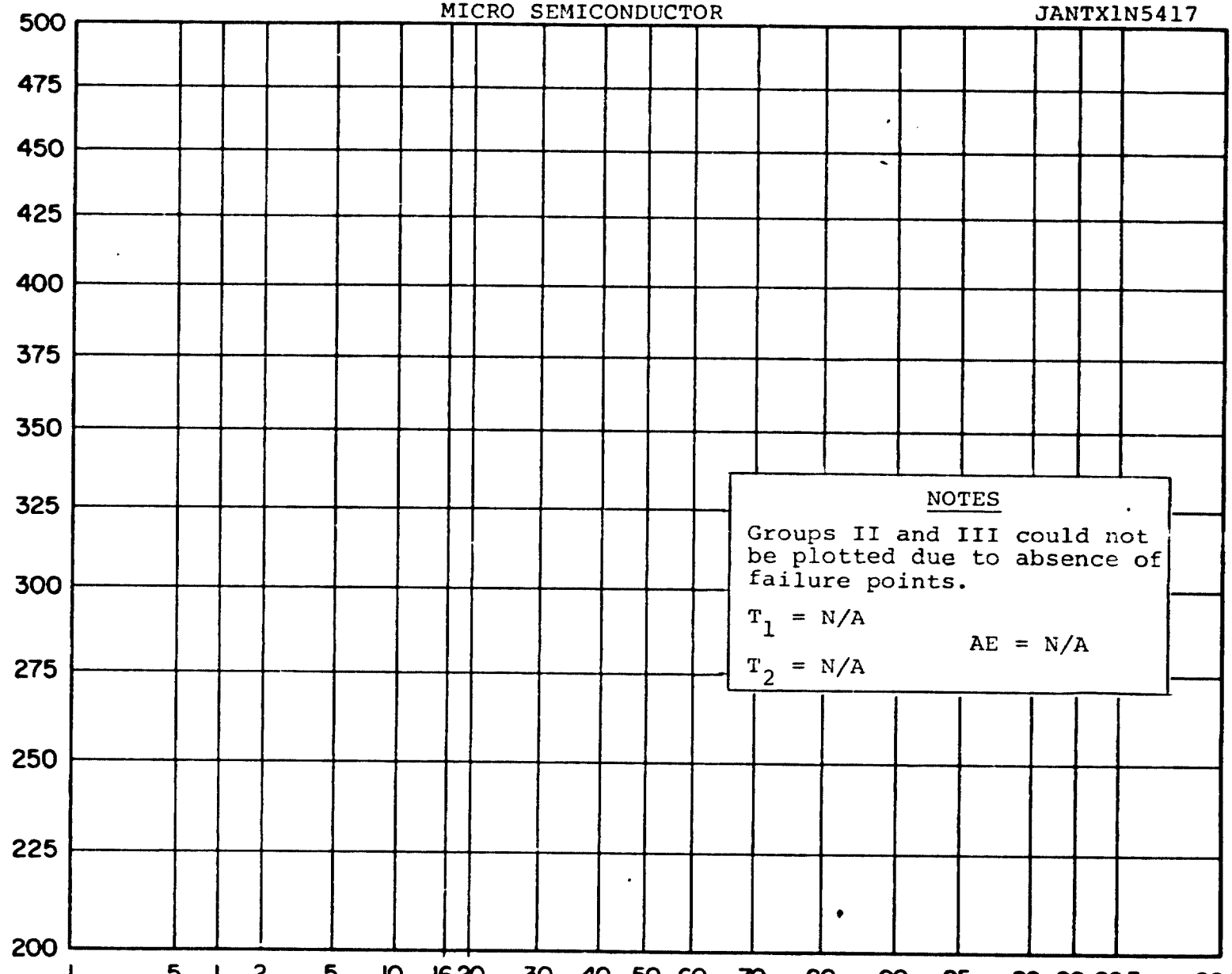


$R_1 = iV/I \pm 1\%$

$P_d = IE$

FIGURE 1

POWER AND TEMPERATURE STRESS CIRCUIT
FOR JANTX1N5417

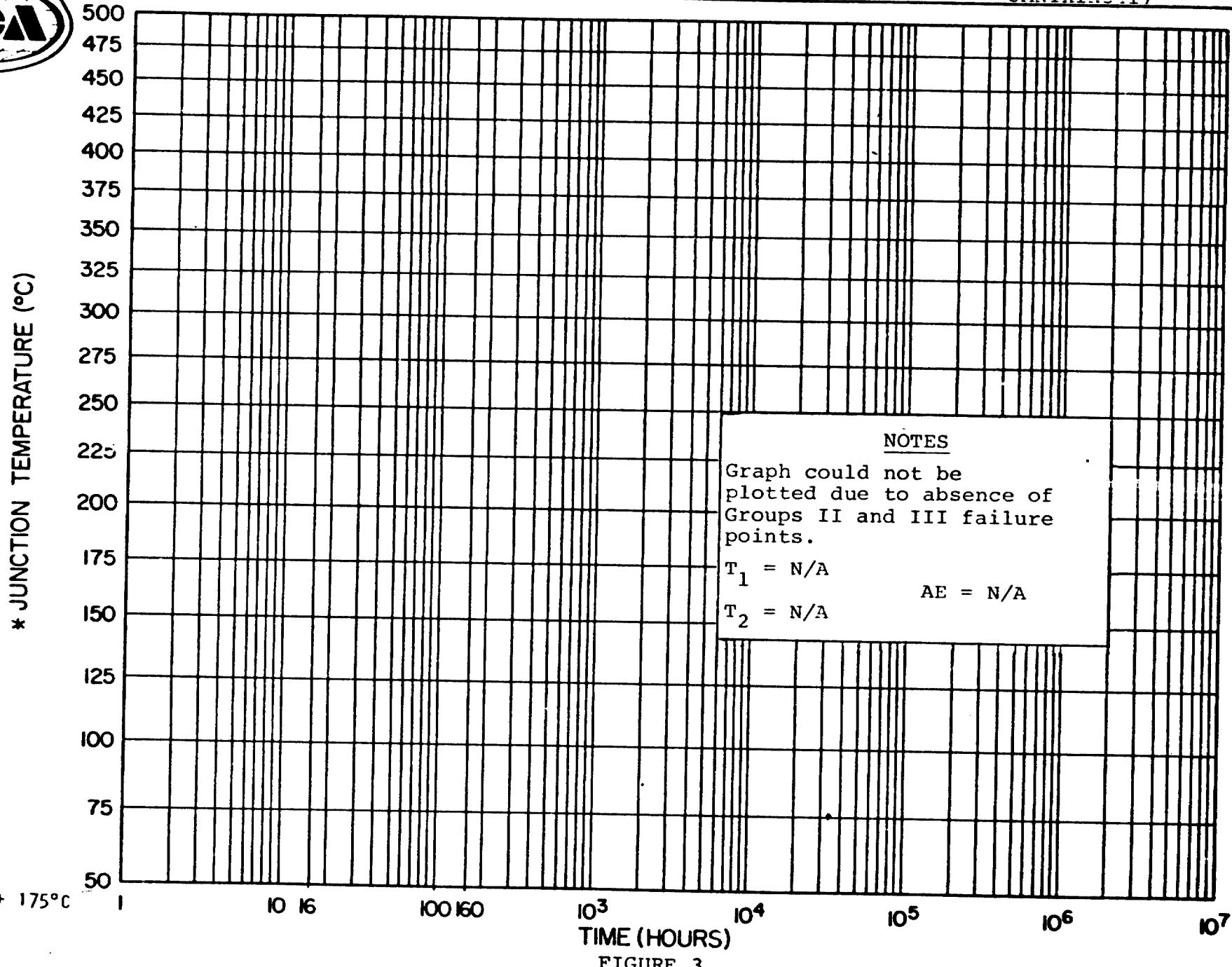


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Micro Semiconductor

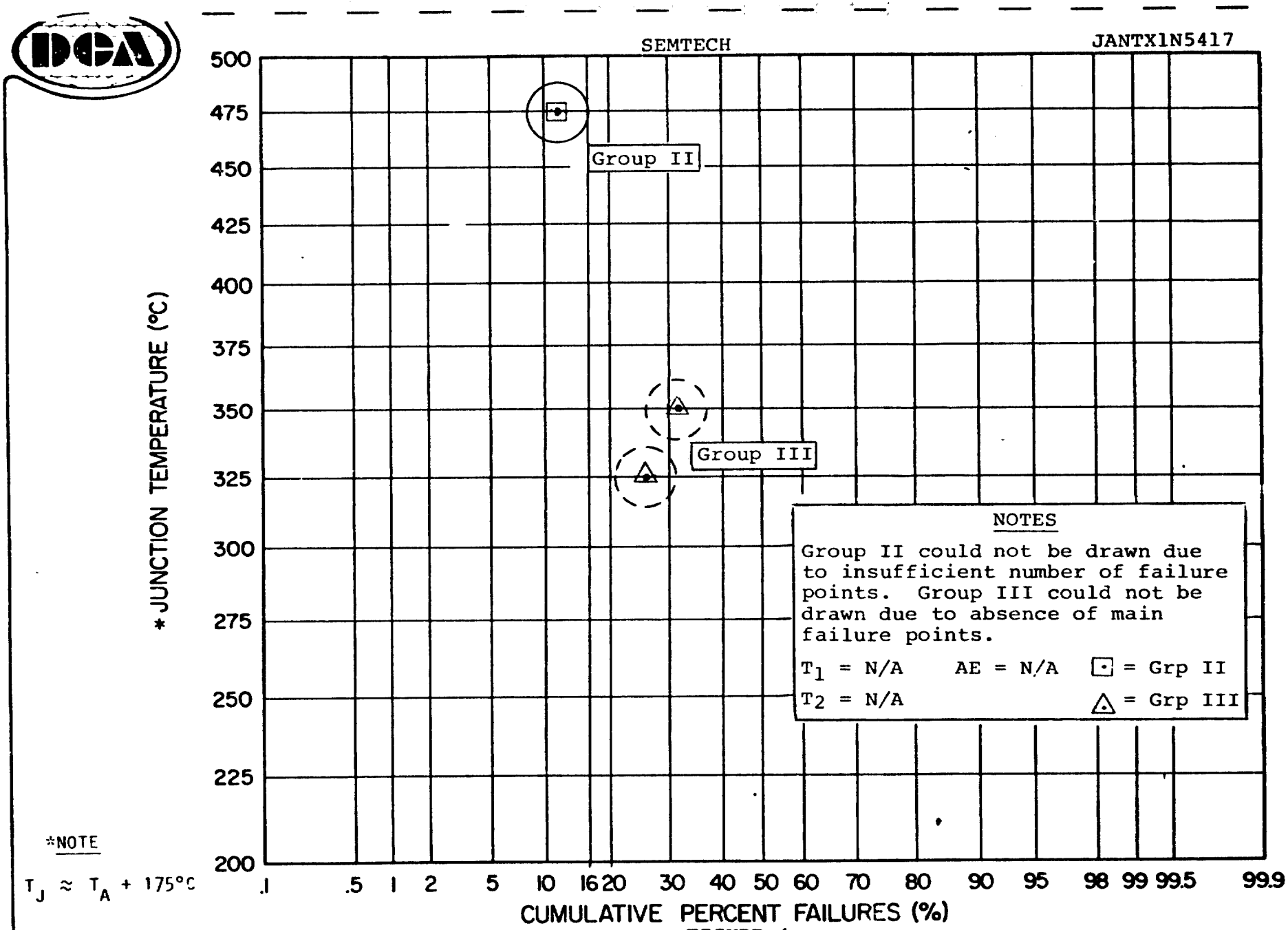
JANTX1N5417



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 3
Time Steps Versus Junction Temperature, Micro Semiconductor

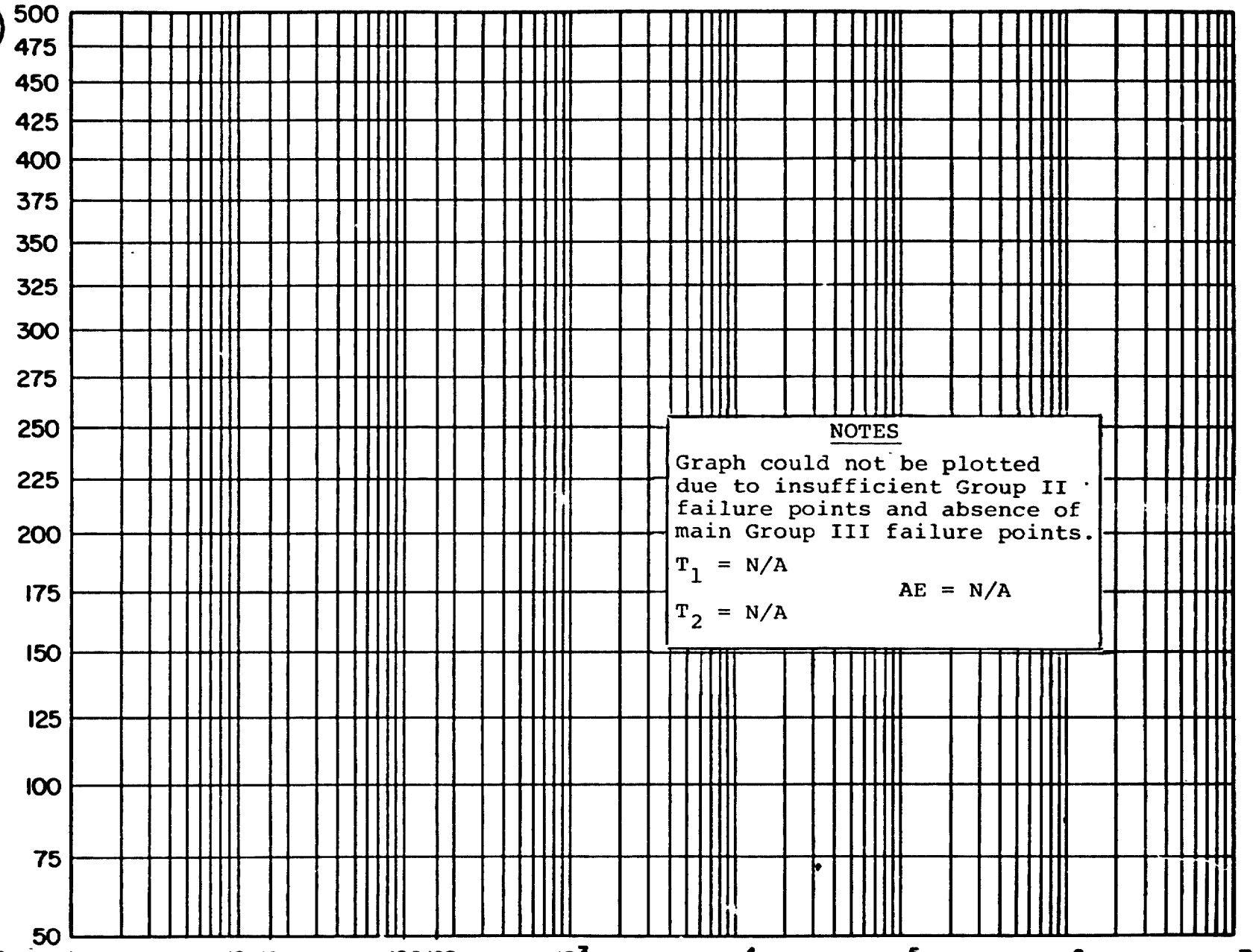


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Semtech



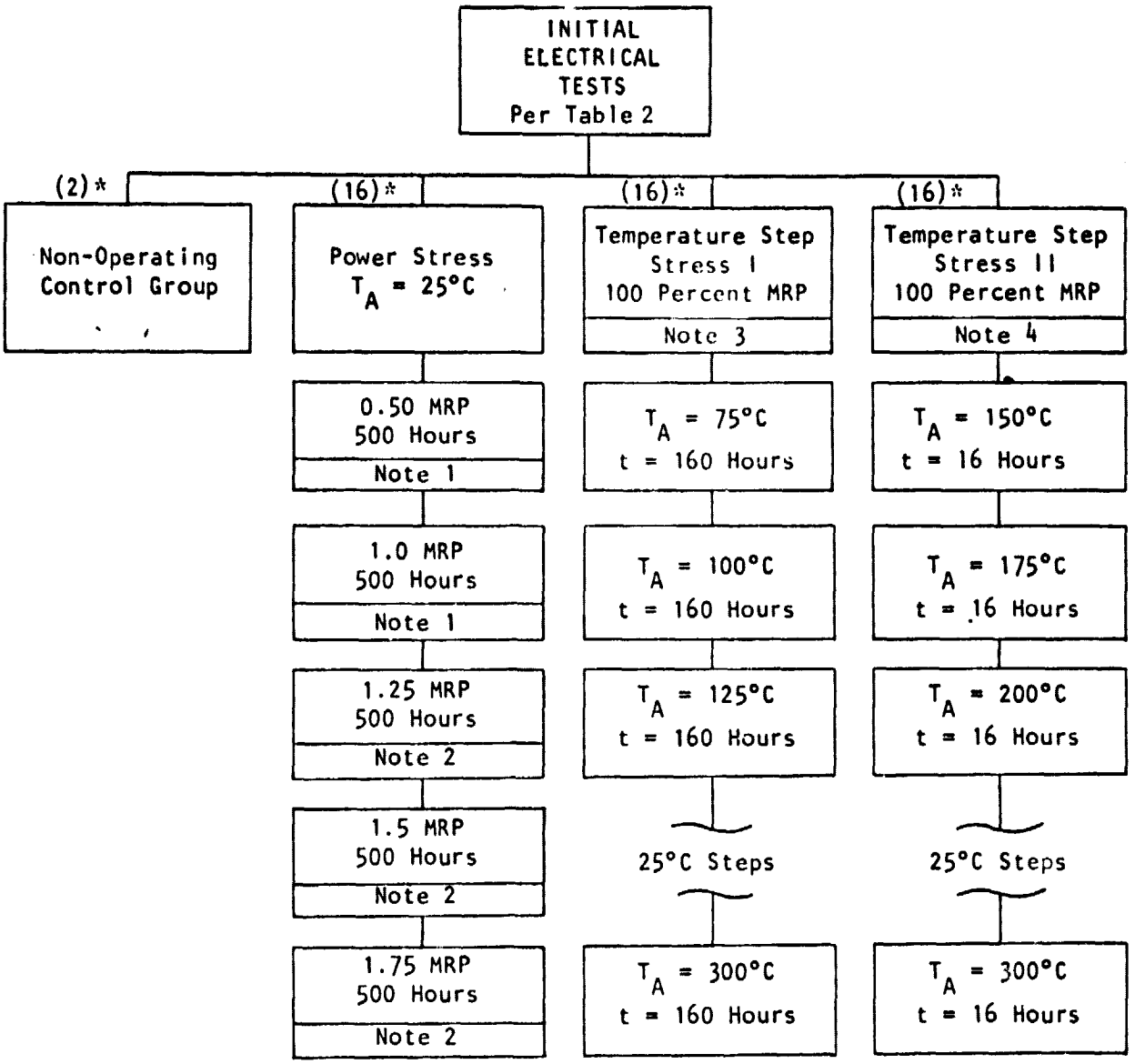
*NOTE

$T_J \approx T_A + 175°C$

FIGURE 5

Time Steps Versus Junction Temperature, Semtech

TABLE I
TEST FLOW DIAGRAM



*Quantity per manufacturer (MICRO SEMICONDUCTOR & SEMTECH)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ V_R = 200V		1.0		100	µA
V_{F1}	@ I_F = 9A (PULSED)	.6	1.5	.3	2.25	V
V_{F2}	@ I_O = 2A (NOT PULSED)	.6	1.2	.3	1.8	V

NOTES:
1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

V_F = 1.0V	
I_F =	Percent P_D
1.8A	50
3.6A	100
4.5A	125
5.4A	150
6.3A	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I — POWER STRESS DATA SUMMARY

PARAMETER	I_R = 1.0μA (MAX)		V_{F1}=.6V(MIN) 1.5V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMIT	@ V_R = 200V		@ I_F = 9.0A(PULSED)		@ I_O = 2.0A (NOT PULSED)			
IDENTIFICATION	MSC	SEM	MSC	SEM	MSC	SEM		
INITIAL DATA								
MIN VALUE	143.0nA	43.10nA	1.060V	1.160V	893.7mV	899.0mV		
MAX VALUE	595.0nA	268.00nA	1.160V	1.430V	926.9mV	1.03V		
MEAN	333.9nA	87.29nA	1.099V	1.285V	915.4mV	947.7mV		
STD DEV	175.5nA	58.20nA	.02249V	.07632V	9.495mV	33.27mV		
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 HRS	-91.2nA	12.81nA	-0.000V	.001V	1.1mV	.6mV		
150 HRS	-109.2nA	9.58nA	.006V	.011V	-0.0mV	-.2mV		
250 HRS	-122.3nA	137.21nA	.008V	.013V	1.0mV	-.1mV		
500 HRS	-81.2nA	*3.491μA	.007V	.012V	-1.7mV	-.3mV		
100% POWER								
550 HRS	-138.6nA	*1.1549mA	.014V	.012V	-.6mV	-.8mV		
650 HRS	-98.7nA	12.68nA	.011V	-.021V	-5.4mV	-20.6mV		
750 HRS	-149.8nA	27.41nA	.003V	-.016V	11.7mV	-15.5mV		
1000 HRS	-156.5nA	-5.18nA	.007V	-.019V	-12.4mV	-19.8mV		
125% POWER								
1010 HRS	-135.7nA	-17.85nA	.009V	-.023V	-4.2mV	-17.8mV		
1025 HRS	-132.1nA	-5.42nA	.017V	-.022V	-.2mV	-16.5mV		
1050 HRS	-77.9nA	2.93nA	.014V	-.025V	-2.5mV	-18.9mV		
1150 HRS	-121.1nA	-13.13nA	.014V	-.017V	2.0mV	-14.1mV		
1250 HRS	-106.2nA	.55nA	.018V	-.018V	3.3mV	-14.7mV		
1500	-50.9nA	22.51nA	-.003V	-.028V	-15.7mV	-25.1mV		

(continued on second sheet)

TABLE 4 (Cont'd)
GROUP I – POWER STRESS DATA SUMMARY

(continued from first sheet)

PARAMETER	I_R = 1.0μA		V_{F1}=.6V(MIN) 1.5V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMITS	@ V_R = 200V		@ I_F = 9.0A (PULSED)		@ I_O = 2A (NOT PULSED)			
IDENTIFICATION	MSC	SEM	MSC	SEM	MSC	SEM		
INITIAL DATA								
MIN VALUE	143.0nA	43.10nA	1.060V	1.160V	893.7mV	899.0mV		
MAX VALUE	595.0nA	268.00nA	1.160V	1.430V	926.9mV	1.030V		
MEAN	333.9nA	87.29nA	1.099V	1.285V	915.4mV	947.7mV		
STD DEV	175.5nA	58.20nA	.02249V	.07632V	9.495mV	33.27mV		
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 HRS	-100.2nA	71.01nA	.010V	-.017V	2.2mV	-14.5mV		
1525 HRS	-37.6nA	167.51nA	.007V	-.021V	1.4mV	-17.4mV		
1550 HRS	-12.7nA	57.31nA	.014V	-.019V	-.4mV	-18.0mV		
1650 HRS	*-115.0nA	107.91nA	.002V	-.032V	-1.4mV	-22.0mV		
1750 HRS	-8.7nA	196.71nA	.006V	-.015V	2.4mV	-13.9mV		
2000 HRS	JOB STOPPED	202.11nA	JOB STOPPED	-.019V	JOB STOPPED	-20.4mV		
175% POWER								
2010 HRS		JOB STOPPED		JOB STOPPED		JOB STOPPED		
2025 HRS								
2050 HRS								
2150 HRS								
2250 HRS								
2500 HRS								
FINAL DATA								
MIN VALUE	140.0nA	106.0nA	1.080V	1.170V	898.0mV	895.0mV		
MAX VALUE	475.0nA	682.0nA	1.120V	1.420V	927.0mV	958.0mV		
MEAN	325.2nA	289.4nA	1.105V	1.266V	917.8mV	927.3mV		
STD DEV	140.9nA	159.8nA	.0150V	.07664V	11.54mV	21.26mV		

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	I_R = 1.0μA (MAX)		V_{F1}=.6V(MIN) 1.5V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMITS	@ V_R = 200V		@ I_F = 9.0A (PULSED)		@ I_O = 2.0A (NOT PULSED			
IDENTIFICATION	MSC	SEM	MSC	SEM	MSC	SEM		
INITIAL DATA								
MIN VALUE	141.0nA	37.60nA	1.070V	1.210V	901.0mV	892.0mV		
MAX VALUE	232.0nA	294.0nA	1.110V	1.440V	923.0mV	995.0mV		
MEAN	180.5nA	82.10nA	1.085V	1.299V	911.0mV	943.0mV		
STD DEV	26.36nA	62.33nA	.01225V	.06528V	7.697mV	27.34mV		
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP (T_A)								
160 / 75°C	-31.1nA	7.59nA	.020V	.016V	-.5mV	2.4mV		
320 / 100°C	-49.1nA	-1.75nA	.021V	.015V	2.4mV	3.9mV		
480 / 125°C	-45.4nA	8.61nA	.024V	.019V	3.4mV	5.8mV		
640 / 150°C	-52.1nA	33.20nA	.023V	.022V	5.4mV	6.5mV		
800 / 175°C	-30.3nA	89.30nA	.021V	.017V	1.4mV	3.2mV		
960 / 200°C	-6.6nA	230.30nA	.006V	.001V	-.6mV	-.3mV		
1120 / 225°C	9.9nA	270.30nA	.021V	.014V	2.9mV	2.1mV		
1280 / 250°C	21.9nA	260.80nA	.019V	-.000V	4.8mV	-1.9mV		
1440 / 275°C	212.9nA	292.70nA	.008V	-.018V	.4mV	-10.2mV		
1600 / 300°C	201.7nA	*40.178μA	0.668V	-.035V	4.7mV	-13.9mV		
FINAL DATA								
FINAL TEMP (T_A)	300°C	300°C	300°C	300°C	300°C	300°C		
MIN VALUE	265.0nA	207.0nA	1.070V	1.090V	902.0mV	874.0mV		
MAX VALUE	582.0nA	520.0μA	1.08V	1.470V	929.0mV	981.0mV		
MEAN	382.2nA	40.26μA	.7774V	1.264V	915.7mV	929.1mV		
STD DEV	92.65nA	127.10μA	.259V	.09624V	8.844mV	27.29mV		

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	I_R = 1.0μA (MAX)		V_{F1}=.6V(MIN) 1.5V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMITS	@ V_R = 200V		@ I_F = 9.0A (PULSED)		@ I_O = 2A (NOT PULSED)			
IDENTIFICATION	MSC	SEM	MSC	SEM	MSC	SEM		
INITIAL DATA								
MIN VALUE	129.0nA	25.90nA	1.070V	1.170V	910.0mV	897.0mV		
MAX VALUE	353.0nA	323.0nA	1.120V	1.420V	944.0mV	981.0mV		
MEAN	179.3nA	87.82nA	1.096V	1.267V	923.9mV	939.8mV		
STD DEV	61.86nA	85.72nA	.01452V	.07104V	8.962mV	29.17mV		
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP (T_A)								
16 / 150°C	289.4nA	*71.06μA	.006V	-.005V	-8.0mV	-8.0mV		
32 / 175°C	200.8nA	*107.51μA	.007V	-.006V	-5.1mV	-7.1mV		
48 / 200°C	113.4nA	164.73nA	-.000V	-.014V	-8.7mV	-11.4mV		
64 / 225°C	218.3nA	400.88nA	.003V	-.011V	-5.3mV	-7.2mV		
80 / 250°C	191.4nA	227.48nA	.005V	-.015V	-1.1mV	-6.7mV		
96 / 275°C	53.8nA	46.78nA	.003V	-.014V	-3.9mV	-9.2mV		
112 / 300°C	104.5nA	199.08nA	.020V	-.009V	3.5mV	-5.0mV		
FINAL DATA								
FINAL TEMP (T_A)	300°C	300°C	300°C	300°C	300°C	300°C		
MIN VALUE	193.0nA	169.0nA	1.090V	1.180V	913.0mV	876.0mV		
MAX VALUE	539.0nA	632.0nA	1.150V	1.370V	949.0mV	978.0mV		
MEAN	283.8nA	286.9nA	1.116V	1.258V	927.4mV	934.8mV		
STD DEV	87.05nA	127.8nA	.01536V	.05739V	9.591mV	29.19mV		

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			MSC	SEM	MSC	SEM	MSC	SEM
I_R		1.0	μA		-.09714	*+57.969	+.02318	*+4.1369	+.16737	*+25.658
V_{F1}	.6	1.5	V		+.03711	-.01315	+.68520	+.00510	+.00629	-.01057
V_{F2}	.6	1.2	V		-.00102	-.01350	+.00243	-.00024	-.00409	-.00780

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N5417

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
100% 50 hr.	0	–	7	B
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
125% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	2	A	0	–
150% 10 hr.	0	–	0	–
15 hr.	1	A	0	–
25 hr.	1	A	0	–
100 hr.	3	A	0	–
100 hr.	5	A	0	–
250 hr.	JOB STOPPED		1	A
175% 10 hr.	JOB STOPPED		JOB STOPPED	
15 hr.	JOR STOPPED		JOB STOPPED	
25 hr.	JOB STOPPED		JOB STOPPED	
100 hr.	JOB STOPPED		JOB STOPPED	
100 hr.	JOB STOPPED		JOB STOPPED	
250 hr.	JOB STOPPED		JOB STOPPED	

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100° C	0	–	0	–
125°C	0	–	0	–
150°C	0	–	0	–
175°C	0	–	0	–
200°C	0	–	0	–
225°C	0	–	0	–
250°C	0	–	0	–
275°C	0	–	0	–
300°C	0	–	2	B

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	–	4	B
175°C	0	–	1	B
200°C	0	–	0	–
225°C	0	–	0	–
250°C	0	–	0	–
275°C	0	–	0	–
300°C	0	–	0	–

MFR "A" - MICRO SEMICONDUCTOR

MFR "B" - SEMTECH

NOTES: A - VISUAL (OTHER THAN HANDLING)

B - I_R > 100μA

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N5417

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	1	A
250 hr.	0	–	0	–
100% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
125% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	1	A	0	–
150% 10 hr.	0	–	0	–
15 hr.	0	–	1	A
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	JOB STOPPED		0	–
175% 10 hr.	JOB STOPPED		JOB STOPPED	
15 hr.	JOB STOPPED		JOB STOPPED	
25 hr.	JOB STOPPED		JOB STOPPED	
100 hr.	JOB STOPPED		JOB STOPPED	
100 hr.	JOB STOPPED		JOB STOPPED	
250 hr.	JOB STOPPED		JOB STOPPED	

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100° C	0	–	0	–
125°C	0	–	0	–
150°C	0	–	0	–
175°C	0	–	0	–
200°C	0	–	0	–
225°C	0	–	0	–
250°C	0	–	0	–
275°C	0	–	1	A
300°C	0	–	0	–

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	1	A	2	A
175°C	0	–	0	–
200°C	0	–	0	–
225°C	0	–	0	–
250°C	0	–	0	–
275°C	0	–	0	–
300°C	0	–	0	–

MFR "A" - MICRO SEMICONDUCTOR

MFR "B" - SEMTECH

NOTES: A - I_R MAXIMUM LIMIT FAILURE

APPENDIX

FAILURE ANALYSIS

FAILURE ANALYSIS

Date 27 October 1978

J/N 2CN242-15A **P/N** 1N5417 **MFR** SEMTECH

FAILURE VERIFICATION: Limit: 2.0μA Max. Limits: 0.3 to 1.8V

S/N		'PIV -volts-	I_R @ 200 V.dc	V_F @ 2 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
/577		short	∞	1.96	33 (150% Pwr.) (25 Hr. Tot.)	I_R
/579		360	0.2μA	1.50	41 (150% Pwr.) (500 Hr. Tot.)	Broken leads
'581		350	0.5μA	1.20	41 (150% Pwr.) (500 Hr. Tot.)	Broken lead

INTERNAL VISUAL INSPECTION:

S/N 7579 and 7581 have lost a portion of one external lead; S/N 7577 has lost an entire lead. See Figures A-1 and A-2.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

FAILURE ANALYSIS

Date 27 October 1978

J/N 2CN242-15A **P/N** 1N5417 **MFR** MICRO SEMICONDUCTOR

FAILURE VERIFICATION: Limit: 2.0μA Limits: 0.3 to 1.8V

S/N		PIV -volts-	I_R @ 200 V.dc	V_F @ 2A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
7641		760	0.3μA	1.25	39 (150% Pwr.) (250 Hr. Tot.)	Lead off
7642		780	0.6μA	1.20	39 (150% Pwr.) (250 Hr. Tot.)	Lead off
7643		760	0.5μA	1.30	39 (150% Pwr.) (250 Hr. Tot.)	Lead off

INTERNAL VISUAL INSPECTION:

All samples have a missing external anode lead and missing external paint. One lead of each device exhibits extreme oxidation, and the other does not. See Figure A-3.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

CONCLUSIONS:

These diodes failed due to thermal effects caused by the excess power of the stress test. Some devices lost an entire lead and others lost only a portion of the lead. Those which lost a portion of a lead (see Figure 2) did so by the development of a high resistance contact to the burn-in clamp.

It is noteworthy that, with the exception of Semtech Sample Number 7757 (which was physically damaged by cracking of the glass case), all these diodes were still acceptable with the MSFC test limits when the leads fell off, even after hundreds of hours of operation at 150% MRP.

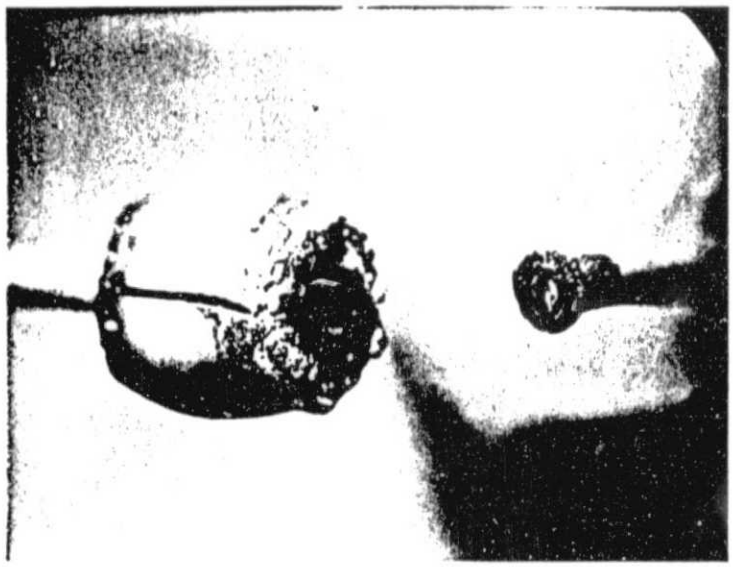


FIGURE 1

S/N 7577, TYPICAL SEMTECH DIODE, 8X.
Note loss of external lead and paint.
This sample also has cracked glass.

FIGURE 2

S/N 7581, SEMTECH, 10X.
Typical appearance of the point
of severance of an external lead.

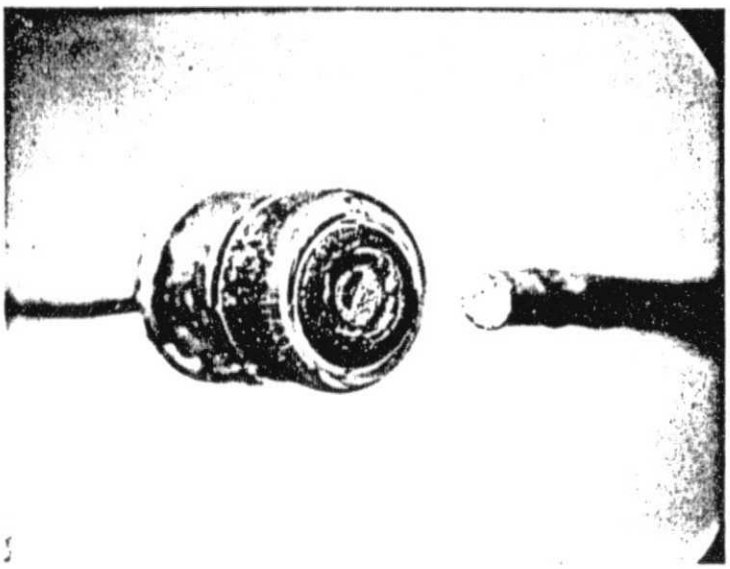


FIGURE 3

S/N 7641, MICRO SEMICONDUCTOR, 8X.
Typical lead detachment and paint loss of diode.